

DARPA Next Generation Internet Program

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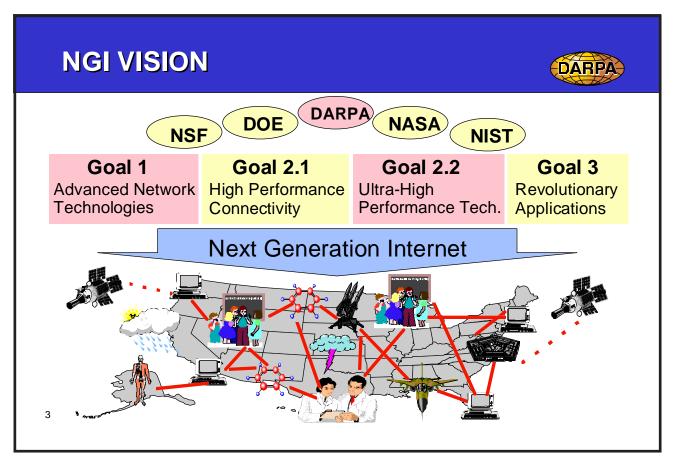
The DARPA NGI program is jointly run by Bertram Hui, Gary Koob and Hilarie Orman.

DARPA IMPACT ON NETWORKING



- ARPANET (Packet Switching): 1970s
- Internet Technologies Transparent Network Interconnect, Addressing & Routing, TCP/IP: 1970s-1980s
- LAN, Packet Radio, and Cellular Systems: 1970s-1980s
- Optical Wave Division Multiplexing: 1990s
- Gigabit Testbeds (with NSF): 1990s
- ATM Technology, ATM and SONET Prototype Network: 1990s
- High Performance Internet Protocols (RSVP, ST2, IPv6, IPSEC, MobileIP, Multicast): 1990s
- MBONE (Conferencing Virtual Multicast Backbone): 1990s

DARPA has been the pioneer of cutting-edge communication technologies. In the seventies, DARPA initiated packet switching and Internet technologies. In the eighties, DARPA was heavily involved in local area network, packet radio and cellular systems. In the nineties, DARPA is one of the key supporters of Gigabit Testbeds. During the same period, DARPA also "gave birth" to ATM and optical wave division multiplexing. Following the same tradition, DARPA will lead the development of the next generation Internet technologies in the coming three to five years.



There are five participating agencies: DARPA, DOE, NSF, NASA and NIST. NGI has three major goals:

1. Experimental Research for Advanced Network Technologies

This goal focuses on research, development, deployment, and demonstration of the technologies necessary to permit the effective, robust, and secure management and end-to-end delivery of differentiated service classes. These activities cluster into three major tasks: Network Engineering, End-to-End Quality-of-Service, and Security.

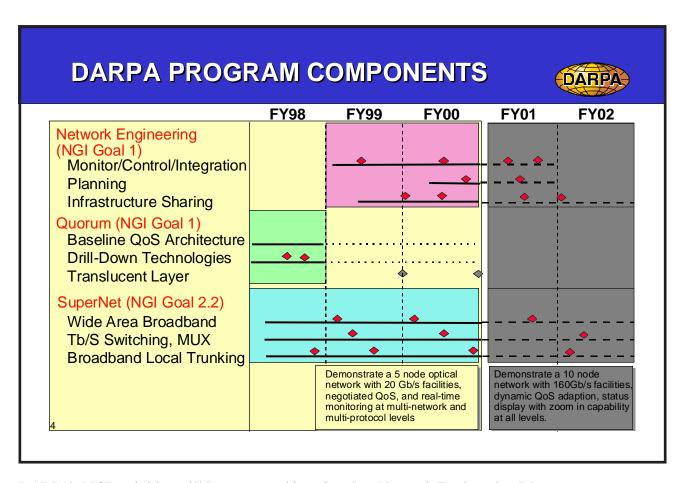
2. Next Generation Network Fabric

<u>Subgoal 2.1: High-Performance Connectivity</u>. Develop a large-scale demonstration network fabric that will function as a distributed laboratory, running at 100+ Mb/s end-to-end, connecting 100+ NGI sites.

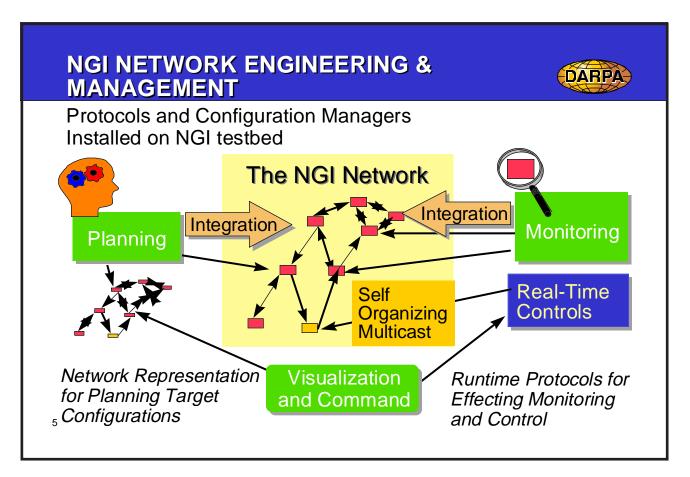
<u>Subgoal 2.2: Next Generation Network Technologies and Ultra-High Performance Connectivity.</u> Develop ultra-high speed switching and transmission technologies, and demonstrate end-to-end network connectivity at 1+ Gb/s involving 10s of NGI sites and applications.

3. Revolutionary Applications

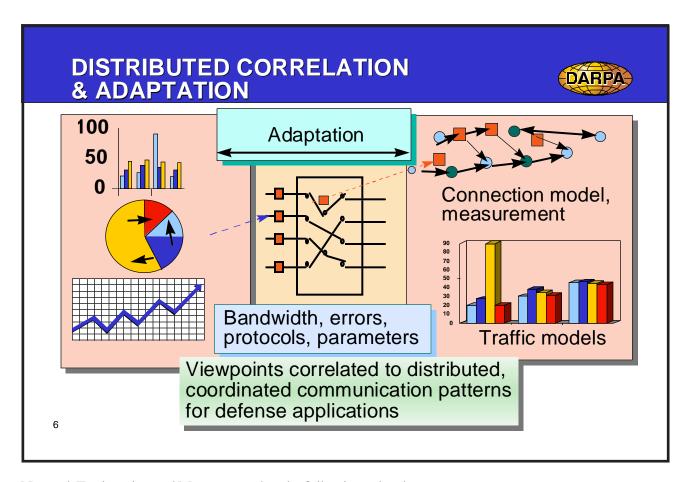
NGI will facilitate revolutionary applications in health care, environment, education, crisis management, basic science, manufacturing and distant learning.



DARPA's NGI activities will be structured into 3 tasks: Network Engineering/Management, SuperNet and Quorum. Both Quorum and Network Engineering will support NGI Goal 1. SuperNet will support NGI Goal 2.2.



The goals of this task are to: (1) create algorithms and tools to enable the planning and operation of networks with scales 100 times those of the current Internet; (2) facilitate management of large-scale internetworks operating at gigabit to terabit speeds; and (3) create an infrastructure partnership in which lead users share facilities with the general public, thereby accelerating the development and penetration of novel network applications.



Network Engineering and Management has the following subtasks:

1. Planning and Simulation

Simulation models and methodology to design networks that may have billions of nodes.

2. Monitoring, Control, Analysis, and Display

Tools to present runtime analysis of distributed communication patterns.

3. Data Delivery

Network nodes that combine methods previously seen as disjoint or mutually exclusive. Examples are best effort and priority traffic, dynamic routing and virtual circuits, greedy admission versus guaranteed delivery, and flat rate versus variable costing.

4. Integration

The goal of this subtask is to ensure that network engineering tools and the high performance transmission and switching technologies can be integrated to manage leading edge user requirements.

NETWORK ENGINEERING:SHARING THE INFRASTRUCTURE

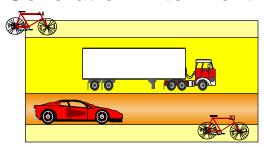


Today

- Core infrastructure is tailored to "average user"
- Research/government testbeds require expensive customized facilities

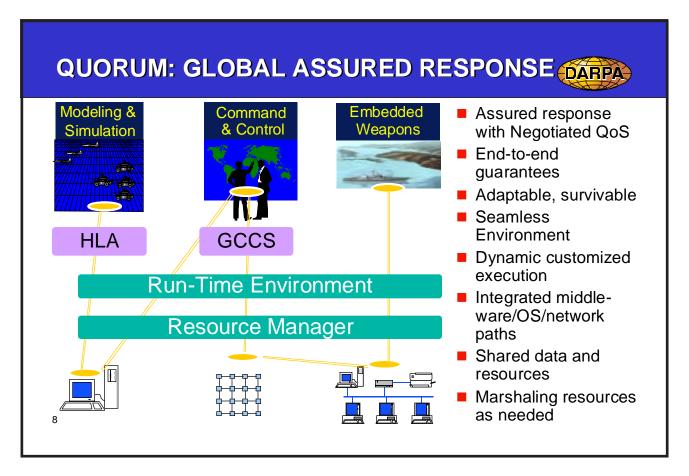
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Generation-After-Next



- Reduce cost
- Accelerate deployment
 - Support 10⁸ average users
 - Support a small number of users with requirements for 10⁴ times the average bandwidth

The final Network Engineering subtask is to investigate new approaches to managing lead user infrastructure. The DoD, DOE, NASA, NSF, and other government agencies, as well as the research community at large, have lead user requirements for telecommunication facilities that require orders of magnitude of speed beyond those of the typical users. This task will investigate architectural concepts, management strategies, and operational arrangements that will allow lead users to concurrently share the same infrastructure substrate as conventional users.

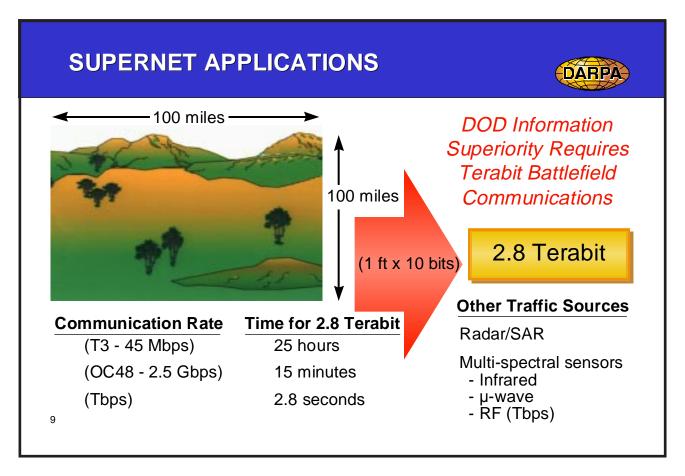


The Quorum task will investigate end-to-end assured response.

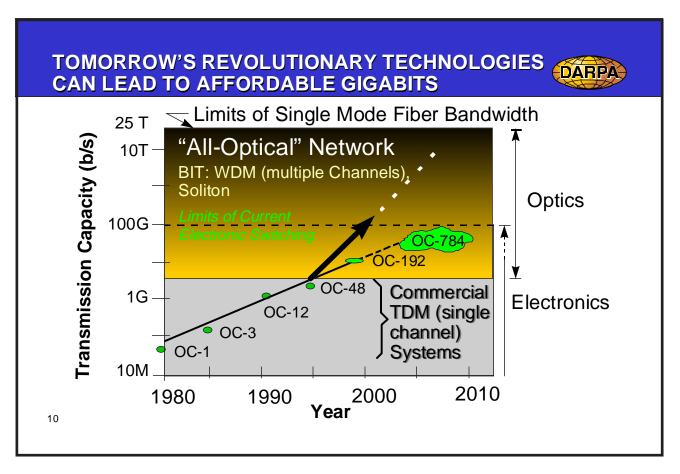
The Quorum resource manager will dynamically discover and allocate global computing, communications, and information resources to meet the immediate demands of an application.

Once allocated, resources will be accessible to the application through Quorum's Run-time Environment or virtual machine interface. The same application will execute correctly and efficiently regardless of the number, types, or locations of the constituent resources. The virtual machine need not be fixed but may be customized to the view appropriate to the application. The view required by a fluid dynamics simulation, for example, may be very different from that required by collaborative planning.

The communications, memory, and execution interfaces of the baseline run-time environment form a substrate that can be tailored to support application-specific environments such as the High-Level Architecture (HLA) for distributed simulation and the GCCS (Global Command and Control System) architecture.



The DoD has many applications that require very high speed connectivity. For example, wideband sensors may collect terabits of information in visible, infrared, microwave and RF regimes. In order to relay this data to the command centers, analysis stations and warfighters, networks operating in the range faster than gigabit per second must be developed.



Conventional single wavelength time-division-multiplexing (TDM) systems with electronic switching have been progressing steadily over the years. DARPA has accelerated overall progress by opening a second "front" in the bandwidth campaign. Our Broadband Information Technology (BIT) program was initiated three years ago to investigate wavelength-division-multiplexing (WDM), and great progress has been made to date.

DARPA BROADBAND INFORMATION TECHNOLOGY PROGRAM



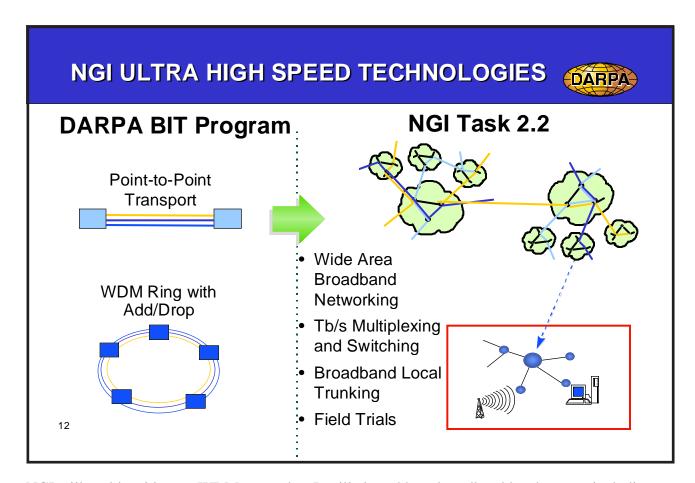


Develop the All-Optical Wavelength Division Multiplexing (WDM) Technologies Necessary to Achieve Four New Physical Layer Networking Services

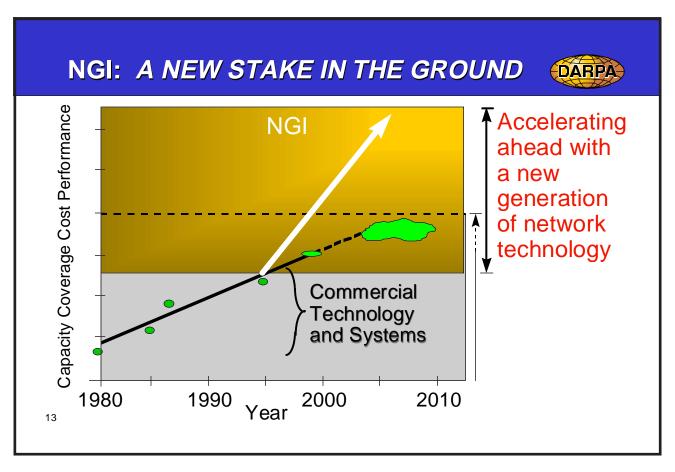
- gigabit per second bandwidth on demand
- rapid, nearly transparent reconfiguration of network routing at the physical layer
- multiplexing of continuous transmission rates from kbps to Gbps
- transmission of analog and digital signals in a single fiber

The BIT program has successfully demonstrated point-to-point WDM transmission over 2000 km with eight wavelengths and 2.5 Gb/s per wavelength. It has also demonstrated all-optical transmission of WDM signals over a local exchange testbed, through an optical cross-connect, around a 2000 km long distance testbed, and back to the local exchange testbed.

WDM network devices have been successfully integrated into OEICs, optoelectronic integrated circuits. Illustrated here is an example of a 20 channel laser array with each laser capable of transmitting at 10 Gb/s. In practice, only eight channels will be lighted up and moderated at 2.5 Gb/s. The DARPA BIT program WDM networks are located at Bellcore/Lucent/AT&T sites in New Jersey, the San Francisco Bay Area and MIT in Cambridge, Massachusetts.



NGI will enable wide area WDM networks. It will also address broadband local access, including wireless trunking. NGI will push the envelope of distributed switching technology to achieve Tb/s capacity through advanced multiplexing schemes.



The NGI effort will develop the technologies to accelerate the pace of capacity deployment. These technologies will enable the carriers and network providers to build the next generation Internet.